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# Mitigating Task Saturation in Critical Care Air Transport Team Red Flag Checklist

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**14. ABSTRACT**
Critical Care Air Transport Teams (CCATTs) are a critical component of the U.S. Air Force aeromedical evacuation paradigm. The complexity of patient care and the nature of the missions require competency in both medical care and technical and non-technical skills (NOTECHS). The current study was conducted to evaluate predictors of competence in non-technical skills. Sixteen CCATTs were studied over a 6-month period. All teams were videotaped during a simulated CCATT mission during their 2-week advanced course at the University Hospital Cincinnati. Team and individual performances were scored using a validated assessment tool for NOTECHS. Salivary cortisol levels were measured at baseline and pre- and post-simulation exercises. Sixteen simulated missions were reviewed, with 69 crisis events identified. Evidence of task saturation was present in 29/69 (42%) crisis events; 63% of participants engaged in intensive unit (ICU) care and 67% had flown real-world CCATT. Each team member was assigned a non-technical skill score or "red flag score." The team's average red flag score correlated with task saturation during the simulated missions (odds ratio 0.5, 95% confidence interval 0.32-0.80, $p<0.01$). In the univariate analysis, daily ICU experience ($p<0.04$), previous attendance at the Center for the Sustainment of Trauma and Readiness Skills course ($p<0.04$), previous experience in simulated CCATT missions ($p<0.04$), and previous deployment experience ($p<0.001$) correlated with the red flag score. In the multivariate analysis, daily ICU experience ($p<0.03$) and previous deployment experience ($p<0.04$) continued to be significant. Salivary cortisol levels increased by 0.124μg/dL over baseline as the result of the simulation ($p=0.0002$) but did not correlate with red flag scores or biographical data, suggesting that the stress of the simulation was similar for all participants. Task saturation is frequently observed in simulated CCATT missions. Non-technical skills correlate with the development of task saturation. Previous real world CCATT experience and daily ICU care correlated with improved NOTECHS. The simulation experience proved to be stressful for the participants.

**15. SUBJECT TERMS**
Critical Care Air Transport Team, CCATT, aeromedical evacuation, task saturation, mitigation

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## TABLE OF CONTENTS

**Section** **Page**

## LIST OF FIGURES

**Figure** **Page**



## LIST OF TABLES

**Table** **Page**

## 1.0 SUMMARY

Critical Care Air Transport Teams (CCATTs) are a critical component of the U.S. Air Force aeromedical evacuation paradigm. The complexity of patient care and the nature of the missions require competency in both medical care and technical and non-technical skills (NOTECHS). The current study was conducted to evaluate predictors of competence in non-technical skills. Sixteen CCATTs were studied over a 6-month period. All teams were videotaped during a simulated CCATT mission during their 2-week advanced course at the University Hospital Cincinnati. Team and individual performances were scored using a validated assessment tool for NOTECHS. Salivary cortisol levels were measured at baseline and pre- and post-simulation exercises. Sixteen simulated missions were reviewed, with 69 crisis events identified. Evidence of task saturation was present in 29/69 (42%) crisis events; 63% of participants engaged in intensive unit (ICU) care and 67% had flown real-world CCATT. Each team member was assigned a non-technical skill score or "red flag score." The team's average red flag score correlated with task saturation during the simulated missions (odds ratio 0.5, 95% confidence interval 0.32-0.80, $p<0.01$). In the univariate analysis, daily ICU experience ($p<0.04$), previous attendance at the Center for the Sustainment of Trauma and Readiness Skills course ($p<0.04$), previous experience in simulated CCATT missions ($p<0.04$), and previous deployment experience ($p<0.001$) correlated with the red flag score. In the multivariate analysis, daily ICU experience ($p<0.03$) and previous deployment experience ($p<0.04$) continued to be significant. Salivary cortisol levels increased by 0.124µg/dL over baseline as the result of the simulation ($p=0.0002$) but did not correlate with red flag scores or biographical data, suggesting that the stress of the simulation was similar for all participants. Task saturation is frequently observed in simulated CCATT missions. Non-technical skills correlate with the development of task saturation. Previous real world CCATT experience and daily ICU care correlated with improved NOTECHS. The simulation experience proved to be stressful for the participants.

## 2.0 BACKGROUND

The U.S. Air Force (USAF) Critical Care Air Transport Teams (CCATTs) have become an integral component of the post-Cold War global patient movement strategy. The teams are assembled utilizing medical providers experienced in the management of the critically ill and are composed of a physician drawn from a small pool of Air Force Specialty Codes, critical care nurses, and respiratory therapists. While their medical training relies on traditional methods such as residency, fellowship training, postgraduate courses, and tech training, team training consists of a CCATT basic course and the more advanced sustainment training performed at the Cincinnati Center for the Sustainment of Trauma and Readiness Skills (C-STARS). Successful completion of both courses is required for teams to be considered deployment ready. Recently published analyses of CCATT missions [1-6] have been instrumental in refining curricular elements of the C-STARS course that pertain to the common medical conditions encountered and expected patterns of illness and injury. However, little is known about the impact of non-technical skills (NOTECHS) on team performance in CCATT missions. In a previous study we performed a detailed analysis of CCATTs during a simulated mission [7] and observed a high incidence of task saturation that correlated with errors in NOTECHS. Task saturation during the simulation was associated with worse outcomes in the simulated patients, suggesting that it is harmful to patient care. However, due to study limitations, we were unable to analyze causative

factors for interteam variability in NOTECHS and task saturation. Given the similarity in team training, we hypothesized that the acquisition of these skills was the result of experiences outside the formal CCATT training. The purpose of the present study was to determine if we could identify the characteristics in an individual's pre-course work experience that would correlate with NOTECHS. To characterize the effect of physiologic stress on performance, we also measured free cortisol levels using a commercially available saliva cortisol assay.

## 3.0 METHODS

Current CCATT training includes a 2-week CCATT basic course at the USAF School of Aerospace Medicine followed by an advanced course at the C-STARS facility at the University of Cincinnati Medical Center in Cincinnati, OH. The advanced course consists of a series of didactic lectures and tabletop discussions focused on the care of the injured and critically ill patient; live patient care on the trauma surgery service, in the surgical and neurosurgical intensive care units, and emergency department; and several simulated CCATT missions. The simulated missions take place in a dedicated facility that replicates many aspects of flight conditions inside a USAF KC-135 airframe during low light conditions, including decking, stanchions, aircraft noise, and only equipment that is compliant with the CCATT allowance standard. Scenarios for simulated missions are developed using data recorded during previous CCATT patient movement missions.

Approval for the use of human subjects in this study was granted by the Institutional Review Boards at the University of Cincinnati as well as the Air Force Research Laboratory, and consent was obtained from 48 CCATT trainees. Sixteen CCATTs were videotaped during performance of identical simulated missions over the course of 6 months. The designated mission involves the care of one critically wounded warfighter and one contractor: one patient with multiple traumatic injuries including a severe traumatic brain injury and one patient with acute coronary syndrome. This scenario was delivered on the Medical Education Technologies, Inc. Human Patient Simulator (METI® HPS®; CAE Healthcare, Sarasota, FL). Video, audio, and simulated patient data, including vital signs, were recorded from the simulator mannequins and from multiple cameras and microphones mounted in the simulation facility. The simulation scenario contained predefined "crisis events," defined as an adverse change in a patient's condition, such as worsening hypotension, hypoxia, self-extubation, or cardiac arrest. These events were time stamped during the recording for later evaluation.

Biographical data (Table 1) were collected from each participant including frequency of previous deployments and previous attendance at the C-STARS course. To guard against performance bias as a result of previous attendance at the C-STARS course, novel simulations were created so that no participant had previously performed the experimental simulation.

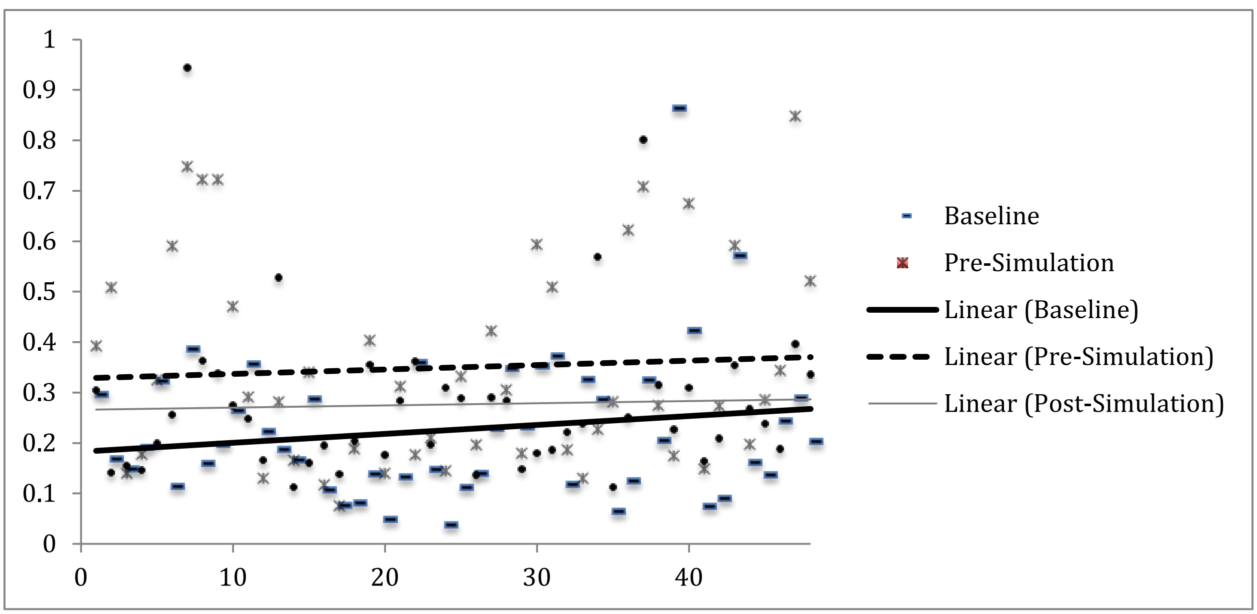
A commercially available salivary cortisol collection and measurement system (Salimetrics, State College, PA) was utilized, and samples were collected from each participant based on the manufacturer's recommendations. Three samples were collected: (1) a baseline sample obtained during the consent process, (2) a pre-simulation sample obtained just prior to entering the simulation, and (3) a post-simulation sample obtained immediately following the conclusion of the simulation.

## Table 1. Summary of Participants

| Position | N | Years Since Highest Degree | Years in Current Position | Daily ICU Experience (%) | Daily Ventilator Management (%) | Primary Employment at Trauma Center (%) | Previously Attended C-STARS (%) | Previous Deployment with CCATT (%) | No. of CCATT Missions | No. of Simulated Missions |
|---|---|---|---|---|---|---|---|---|---|---|
| MD | 16 | 7.5 | 3.5 | 15 | 40 | 55 | 45 | 55 | 14 | 5 |
| RN | 16 | 6.7 | 5.9 | 89 | 55 | 39 | 39 | 83 | 17 | 3.6 |
| RT | 16 | 5 | 6 | 86 | 64 | 28 | 64 | 64 | 22 | 5.7 |
| Total or Mean | 48 | 6.4 | 5 | 63 | 53 | 41 | 49 | 67 | 17.7 | 4.7 |

MD = physician; RN = nurse; RT = respiratory therapist.

A panel of experts in critical care and medical education reviewed the videotaped missions and evaluated team and individual performance during each crisis event, utilizing a rating tool adapted from previously validated tools designed to identify barriers to effective teamwork during cardiac arrests [8,9] and evaluate team performance during an anesthesia crisis [10]. The principal categories of evaluation include teamwork, communication, mutual performance monitoring, maintenance of standards and guidelines, task management, procedural skill, and equipment management. Four performance characteristics were evaluated in each domain to achieve the final score. Each evaluator noted the presence or absence of task saturation during each crisis event as well as the type of behavior exhibited by the team member during events that were categorized as task saturated. In addition, each team member's NOTECHS were evaluated using a validated, 7-point Likert scale [11]. The raters were blinded to the experience data collected and summarized in Table 1 and to the cortisol data in Figure 1. A composite Likert scale was used to assign teams a score from 1 to 7 in each of the performance domains.



Logistic regression analysis was used to determine the association between performance domains and task saturation for these two groups and Fisher's exact test was used to determine the association between task saturation and adverse clinical outcomes.

## 4.0 RESULTS

Data on all 48 participants were collected and are summarized in Table 1. Sixty-three percent of the participants reported that their duties required daily care of a patient in an intensive care unit and 53% stated that this required daily management of a ventilated patient. Forty-one percent of the participants are assigned to hospitals with a verified trauma center designation. Sixty-seven percent of the study group had previously participated in real-world CCATT missions and had flown an average of 17 times prior to their performance in the simulation. Forty-nine percent of participants attended the C-STARS course previously with an average of 4.7 simulated missions per student.

During the simulations, data were obtained for 69 crisis events. Task saturation was observed in 29 (42%) of the crisis events, with target fixation being the most common associated behavior (20/29), followed by compartmentalization (6/29) and shutting down (3/29). Task saturation was strongly associated with poor performance in team communication (odds ratio (OR) 0.71, 95% confidence interval (CI) -.51-0.98, $p<0.01$), situational awareness (OR 0.53, 95% CI 0.35-0.81, $p<0.01$), and problem solving (OR 0.42, 95% CI 0.24-0.72, $p<0.01$). There was no correlation between task saturation and equipment expertise, procedural skill, or medical management of the critical event.

Each team member was assigned a NOTECHS score based on the domains of leadership, problem solving skills, situational awareness, resource utilization, and communication, and a total score was generated as the "red flag score" (Table 2) using a Likert scale from 1 to 7, with a 35 being the highest (and therefore the best) score attainable. There was no statistical difference in the average red flag score for the three provider types (MD 4.0, RN 5.11, RT 4.87). The team's red flag score correlated with the incidence of task saturation during the simulated missions (OR 0.5, 95% CI 0.32-0.80, $p<0.01$). The higher the score, the lower the incidence of task saturation.

**Table 2. Red Flag Scores**

| Position | Leadership | Problem Solving | Situational Awareness | Resource Management | Communication | Average Red Flag Score | Total Red Flag Score |
|---|---|---|---|---|---|---|---|
| MD | 3.7 | 4.1 | 4.1 | 4.2 | 4.1 | 4 | 20.5 |
| RN | 5 | 5.2 | 5.2 | 5.2 | 5.1 | 5.1 | 28.3 |
| RT | 4.4 | 5 | 5 | 5.2 | 4.5 | 4.9 | 24.1 |

The biographical data of each participant were then assessed to determine if there were any predictors of strong NOTECHS as measured by the red flag score (Table 2). In the univariate analysis, the following were significant: daily intensive care unit (ICU) experience ($p<0.04$), previous attendance at the C-STARS course ($p<0.04$), previous experience in simulated CCATT missions ($p<0.04$), and previous deployment experience ($p<0.001$). In the

multivariate analysis, only daily ICU experience ($p<0.03$) and previous deployment experience ($p<0.04$) continued to be significant.

Average salivary cortisol level just before entering the simulation was 0.35 μg/dL, an increase of 0.12 units from baseline (0.23 μg/dL). This difference was statistically significant ($p=0.0002$). The mean cortisol level on completion of the simulation was still elevated relative to baseline, but was significantly lower than pre-simulation levels (0.28 μg/dL, $p=0.0002$). This was true across all participants and teams and did not correlate with red flag scores or biographical data, suggesting that the stress of the simulation was similar for all participants.

## 5.0 DISCUSSION

The performance of the USAF aeromedical evacuation crews and CCATTs over the past decade of war has been nothing short of remarkable. The capability of these crews to transport increasingly complex patients has changed the paradigm of military medical care from one that largely relies on a heavy presence in theater to one that can rely on established medical assets all over the world. This evolution has been taking place over the past 30 years largely in response to the need for agility in the care of the injured patient and the requirement to deploy and redeploy rapidly [12]. Along with increasing use of damage control procedures in far forward settings, increased emphasis has been placed on stabilization and rapid evacuation of casualties [13]. The goal of a CCATT is to turn almost any airframe into a flying ICU. The initial strategy called for patients to be stabilized in a forward theater of operations and then transported within 72-96 hours, but this window has shrunk as frontline care and transport capabilities have matured. Each CCATT consists of three members (physician, critical care nurse, and respiratory therapist), each with unique and highly specialized training and capabilities. Even though patients are stabilized prior to transport, flights may last up to 16 hours and teams must be equipped to recognize and respond to changes that arise in these complex and critically ill patients.

A recent review of CCATT missions by Ingalls et al. confirms the effectiveness of the current strategy. Between 9/11 and December 31, 2010, 2899 CCATT transport records were received by the Global Patient Movement Requirements Center. Of these, data from 975 complete missions were available for review. A review of this data set confirms that CCATTs are actively involved in the ongoing resuscitation of critically ill patients, requiring proficiency with a diverse set of skills from transfusion medicine to neurocritical care. The typical patient was a male U.S. Army soldier with an average age of 26. The average injury severity score for the entire group was 23.7, and the time from stabilization until arrival at Landstuhl Regional Medical Center was 38 hours. Many of the patients were intubated and mechanically ventilated, indicating the complexity of care required [14,15]. The median Glasgow Coma Scale score in the former review was 6 (range 3-15) [16], demonstrating the need for CCATTs to be proficient in the management of the head injury patient. Extremity amputations, injury from bomb fragments, acute coronary syndromes, and long bone fractures are also commonly encountered during these missions [1].

The overall 30-day mortality in the previous review was 2.1% and the mortality en route was less than 0.02% [16]. It is clear that CCATTs have achieved excellent results with a high level of acuity in care, but there are no data available on the variability in performance between teams. The students in C-STARS training courses are drawn from multiple different training backgrounds and practice settings. Only 41% of participants practice at a verified trauma center,

while 63% have exposure to daily ICU care, which may impact their exposure to the types of injuries that are encountered during real-world missions. It is even less clear what type of background and training C-STARS participants have in NOTECHS. While the resuscitation and clinical management of critically ill patients require sound medical judgment and training, competency in NOTECHS such as leadership, problem solving, situational awareness, communication skills, and resource management is also critical. These NOTECHS have previously been described as crisis resource management (CRM) [11]. Poor performance in these domains and not medical knowledge has frequently been cited as a cause of medical errors [17]. The concept is similar to crew resource management and has been studied using validated tools in the medical community. Studies of team performance demonstrate that professional experience alone does not automatically lead to the acquisition of NOTECHS [18].

In the teamwork literature, CCATTs would fall under the category of "action work teams," composed of members with diverse specialized skills and performing in dynamic and often unpredictable environments [19]. The concept of task saturation was originally developed as it applied to flight crews, another example of an action work team with a dynamic, high-stakes work environment. However, task saturation can occur in any team or individual where there are multiple demands on time, attention, and resources. It has been suggested in such disparate work sets as triage of trauma patients [20], cardiac arrest resuscitation [8], evaluation of surgical floor patients [21], and operating room crises [10]. A review of previous CCATT missions as well as studies describing the acuity of patients during civilian air transport reinforces that conditions exist in which task saturation may be prevalent [22,23]. Our previous study showed that task saturation occurred in CCATTs during simulated missions and was common and associated with non-technical human errors and worse simulated patient outcomes [7]. The importance of non-technical or non-medical skills in healthcare has already been well documented and is especially crucial in active work teams [24]. Communication failure has been demonstrated in 30% of team exchanges in the operating room and was shown to be the primary root cause of patient harm in 70% of sentinel events [25]. Similarly, Wiegmann et al. found that 52% of disruptions in flow of cardiac surgery were due to teamwork and communication problems [26]. Teamwork, communication, and performance monitoring have surfaced in multiple other studies as a leading cause in incident and adverse event reports [27-30].

The present study supported our previous finding that task saturation is a common occurrence during simulated high acuity missions and is linked to key CRM skills. In the univariate analysis, daily ICU experience, previous attendance at the C-STARS course, previous experience in simulated CCATT missions, and previous deployment experience predicted superior NOTECHS and lower rates of task saturation. Daily ICU care and previous deployment experience remained significant in the multivariate analysis. This may reflect the fact that the CCATT advanced course is primarily focused on acquisition and refinement of technical skills and knowledge without specific training in the core domains of CRM. There is evidence that specific simulator-based training can improve individual and team performance in CRM [28,31]. However, it is less clear how well such training would translate into clinical experience and outcomes. In a review by Boet et al., only nine studies were found that addressed this question. Three out of four studies found that simulation-enhanced CRM training led to improvement in skills that translated into clinical practice, while only one out of five showed that CRM training led to improved patient mortality [32]. Hansel et al. showed that neither a 1.5-day simulator course or a 1.5-day CRM course on situational awareness led to improved clinical performance in a group of senior medical students [33]. Together, these findings suggest that while it is

possible to teach crucial CRM skills that influence clinical practice, it is not a simple or straightforward process, and more work remains to develop reliable systems for doing so. As deployment experience begins to decline, the importance of developing platforms to improve NOTECHS remains critical, as does careful selection of CCATT members.

Of the three recognized coping mechanisms that people employ when faced with task saturation [34], our study confirmed that target fixation was by far the most common. This is when a person becomes intensely focused on one thing at the expense of everything else. Other tasks are neglected and ignored and new tasks accumulate. This information can assist in the evaluation and implementation of new curricula including the creation of "check lists" to redirect team members when actions do not result in the expected outcomes. Specific knowledge of this coping mechanism may also reduce the incidence of linear thinking in which tasks are completed one at a time without regard to priority. Shutting down, where someone either quits the task or takes frequent breaks, and compartmentalization, where a person acts busy but accomplishes little, were also observed but with much lower frequency.

Previous studies have suggested that physiological stress significantly impairs performance during simulated intra-operative emergencies, although increasing clinician experience was effective in minimizing its impact [35]. We sought to determine if a similar effect could be demonstrated during the simulated missions and if the association with clinician experience would influence the results. While our data failed to demonstrate any correlation between stress, team performance, or individual experience, it did confirm that the simulation itself was stressful to the participants. This has been shown in a previous study using high fidelity simulation, which also failed to demonstrate a reduction in stress as the result of CRM training [36]. The fact that the students experienced stress as a result of the simulation is significant in confirming their "suspension of disbelief" as it relates to the realistic nature of the training and the importance it plays in preparation for real-world missions.

Effective management of the complex patient requires the coordinated efforts of a team. Extreme time pressures, diagnostic uncertainty, and rapidly evolving situations can challenge even the most experienced providers. Individuals may not be equipped to bring sufficient cognitive resources to bear to resolve high-level, dynamic challenges. In these situations, team-based skills are required [31]. Our study has significant implications for the future training of CCATTs attending the advanced course at the University of Cincinnati Medical Center, and further study is required to determine if CRM training alone is enough to mitigate the impact and incidence of task saturation on team members.

## 6.0 CONCLUSIONS

Task saturation is frequently observed in simulated CCATT missions. Non-technical skills correlate with the development of task saturation. Previous real-world CCATT experience and daily ICU care correlated with improved NOTECHS. The simulation experience proved to be stressful for the participants.

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## LIST OF ABBREVIATIONS AND ACRONYMS

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|---|---|
| **CCATT** | Critical Care Air Transport Team |
| **CI** | confidence interval |
| **CRM** | crisis resource management |
| **C-STARS** | Center for the Sustainment of Trauma and Readiness Skills |
| **ICU** | intensive care unit |
| **MD** | physician |
| **OR** | odds ratio |
| **NOTECHS** | non-technical skills |
| **RN** | nurse |
| **RT** | respiratory therapist |
| **USAF** | U.S. Air Force |